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MINISTRY OF SUPPLY

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RESEARCH AND DEVELOPMENT

MECHANICAL MIXING OF SCREENING SMOKE

By C. J. STAIRMAND
Directorate of Ordnance Factories (Filling)

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ABSTRACT

This report describes the development of mechanised equipment for preparing screening smoke compositions on a very large scale. Machinery for preparing the ingredients and mixing the final composition is described, the outputs being of the order of 200,000 lbs. per week per unit, employing 8 - 10 operatives on three shifts.

The advantages which accrue from the use of this type of equipment are:-

(i) Very greatly increased output per operative hour, compared with the hand methods.

(ii) Improved regularity of the prepared compositions.

(iii) Improved flowing properties of the powder, permitting the use of automatic weighing and filling machines without further granulation or other treatment.

(iv) Vastly improved working conditions due to the comparative absence of dust and fumes.

MECHANICAL MIXING OF SCREENING SMOKE

CONTENTS

I. DEVELOPMENT OF MECHANISED MIXING EQUIPMENT.

In the preliminary experiments attempts were made to use the standard 12" diameter hexachlorethane storage cans as mixing drums, fitting a special collapsible wooden baffle during the mixing cycle. However, in view of the rapidly increasing commitments a larger type of integral baffle drum was developed holding a charge of 250 - 300 lb.

It was soon evident that the problem with these particular compositions would be to avoid sticking of the powder to the vanes and to the wall of the drum; it was never difficult to secure adequate mixing or end to end circulation. The early models of this large type drum mixer were made from ordinary mild steel sheet. While this proved satisfactory for the preliminary experiments, it was soon obvious that a smoother surface was necessary for the production plant. Accordingly all later models were made in highly polished stainless steel, the baffles being detachable so that the drum could be repolished when necessary. However, the production models have now mixed some 10,000,000 pounds of composition each without re-polishing.

There are five important points to be observed with this equipment. (It should be borne in mind that the object is to ensure satisfactory mixing with an extremely rapid change-over with no moving parts within the drum, to avoid explosion hazards).

(i) The drum must be rotated at exactly the right speed. 36 r.p.m. for a 24" diameter drum is correct.

(ii) The powder must not overfill the drum. 33% by volume is the correct filling.

(iii) The baffles should stand 1/2" clear of the drum to avoid build-up of powder at the inside corner. This is achieved by supporting the baffles at the ends only and constitutes the most important feature of the whole arrangement.

(iv) Axial baffles are preferable to inclined vanes, thus avoiding the acute corner which is a disadvantage with the latter type, and leads to cleaning difficulties.

(v) The mixing time is fairly important but is not critical, provided that time is given for the powder to consolidate properly, followed by a 15 minute mixing period. Normally, with the bulky oxide powders the drum is overfilled at the start of the cycle, but consolidates to approximately 33% filling after about 5 minutes mixing. The cycle is completed in a further 15 minutes, i.e., a total cycle of 20 minutes.

II. PRE-TREATMENT OF INGREDIENTS.

In order to obtain the ingredients in a state suitable for mixing they must be pre-treated.

The mixtures dealt with in this report are in general of two types:-

(i) Calcium Silicide mixtures containing -

Zinc oxide
Calcium Silicide
Hexachlorethane
with 2% Potassium Nitrate as stabiliser.

(ii) Zinc Dust mixtures containing -

Zinc Dust
Zinc Oxide
Sodium Chromate
Hexachlorethane.

These ingredients are pre-treated as follows:-

(i) Zinc Oxide. This material is normally supplied in a fine state of sub-division, but it is very sticky and must be sieved through a coarse mesh sieve (25 B.S.) immediately before use. Owing to the extreme stickiness of zinc oxide this sieving operation is most difficult, but a special Finex* sieving machine, fitted with spreader brushes, has given through-puts up to 1,000 lb. per hour and is now standard for this duty. (See refs. 2 and 3).

The zinc oxide does not normally require drying, but when this operation is necessary a Gardner** spiral bladed steam-heated dryer has been found satisfactory.

(ii) Hexachlorethane. This ingredient presents the greatest difficulty since it must be ground very finely to ensure satisfactory mixing, and in this fine state agglomerates rapidly. Thus it may be pre-treated immediately before mixing. On the other hand, if it is too fine it "balls-up" in the mixing process and so it is not satisfactorily distributed in the final mix.

These difficulties have been overcome in the production layout by incorporating a multiple pre-treatment unit comprising:-

(1) A mechanical jaw crusher for crushing large hard lumps of Hexachlorethane.

(2) A high speed rotary disintegrator which treats the material from the jaw crusher so that the majority of it passes 100 mesh with 100% passing 25 mesh.

(3) A Finex Sieving Machine, with spreader brushed (see refs. 2 and 3) which is used immediately before the mixing process and breaks up any aggregates. Normally all three machines are used in series, but in certain cases, for example with very "soft" hexachlorethane, the jaw crusher and even the disintegrator may be by-passed; the sieve must be used in all cases in order to prepare the material in the correct form for satisfactory mixing.

* Marketed by Russell Construction Ltd., John Adam Street, London, W.C.2.

** Marketed by Gardners Ltd., Gloucester.

(iii) Calcium Silicide. This material is normally received in a condition satisfactory for mixing but is passed through a 25 mesh sieve to remove foreign bodies. This is essential since metal objects such as nails, etc., are often found in the commercial supplies. If it is necessary to dry the Calcium Silicide an ordinary Gardner Drier (above) is satisfactory.

(iv) Potassium Nitrate. This material acts as a stabilizer and is required in an extremely fine state of subdivision. It is best prepared by passing through a high speed beater mill, such as a K.E.K. mill, and is passed, by hand, through a 100 mesh sieve immediately before use.

(v) Sodium Chromate. This material is the stabilizer used with zinc dust compositions and must be ground finely. A high speed pulverisor is used in this case followed by sieving on a 12 mesh totally enclosed sieve. The major difference between Sodium Chromate and Potassium Nitrate, so far as pre-treatment is concerned, is that the former is much harder to grind and a considerable proportion of oversize particles must be re-cycled. The powder is very toxic, rapidly producing chromic ulcers, and efficient dust extractor plant is essential. As a further precaution the powder is always pre-mixed with the appropriate quantity of zinc dust before removing to the main mixing shop.

III. FINAL DESIGNS.

A typical production layout is shown opposite. The principle is to pre-treat all of the ingredients separately, adding the stabilizer at the most convenient point. The batches of ingredients are weighed out in 12 lots, sufficient to give a total charge of 250 - 300 lb., which is varied between these limits according to the bulk density of the ingredients, particularly the zinc oxide. A change is seldom required and the operatives soon learn by experience when a particular batch of powder is likely to over-fill the drum. The latter should never be more than half full at the commencement of the mixing cycle nor more than 1/3rd full at the end. For Calcium Silicide mixtures the Zinc Oxide and Hexachlorethane, the major ingredients, are pre-blended after weighing out, the Potassium Nitrate being added to each lot before pre-blending. The Calcium Silicide is normally added direct to the drum in two lots after the 4th and 8th tray of pre-blended Zinc Oxide and Hexachlorethane, but modifications to this procedure may be necessary for convenience or for other reasons.

In the case of Zinc Dust mixtures the Sodium Chromate and Zinc Dust are always pre-mixed in a special shop away from the main mixing shops. This is on account of the extreme toxicity of the chromate, but may also be expected to give improved stability since the chromate and zinc dust are most intimately mixed.

A similar procedure may be adopted for the Silicide smokes if desired, the Silicide and Potassium Nitrate being pre-mixed. This undoubtedly gives better distribution of the stabilizer but it should be remembered that Silicide-Nitrate mixtures are very sensitive and special precautions are necessary to avoid explosion hazards.

IV. SUMMARY AND CONCLUSIONS.

The apparatus described in the foregoing pages has at the time of writing been in operation for about three years, during which time it has mixed some 10,000,000 lb. of composition. Prior to 1941, screening smoke compositions were made in limited quantities by passing the prepared ingredients two or more times through fairly coarse sieves; while the results obtained were in general satisfactory in view of the comparatively small outputs, the method suffered from a number of disadvantages, viz.:-

(i) Outputs per operative per hour were low.

(ii) The personal factor was unduly prominent.

(iii) The working conditions were bad, particularly in the blackout hours, when ventilation was necessarily less efficient.

(iv) The compositions so prepared were fluffy and flowed and pressed badly, unless subjected to further treatment.

This further treatment consisted of a final mix for about 10 minutes in a Peerless mixer. While this resulted in partial granulation of the powder and improved its pressing properties it introduced an undesirable element of risk. Accordingly, attempts were made to develop a completely new type of mixing equipment based on the straight vaned drum mixers which had given satisfactory results with Incendiary and Tracer compositions for Small Arms Ammunition (Ref. 1).

No design changes have been found necessary in any part of the process. but it has been demonstrated repeatedly that strict adherence to the original methods of operation are essential. In particular, observance of the following points is necessary:-

1. The ingredients must be pre-treated as indicated. No wide divergence from the specified sieve meshes can be made.

2. The ingredients must be dry. This is necessary to prevent "balling-up", but since it is also essential to avoid the presence of moisture on account of the instability of the compositions in presence of water no new principle is involved.

3. Accumulations of powder must not be allowed to build up inside the drum. It is recommended that the interior be lightly brushed out after each mix.

4. The dimensions of the drum and baffles are important.

5. The speed should be controlled to within + 2 r.p.m. (34 - 38 r.p.m. for a 24" internal diameter drum).

6. The drum should never be more than half filled and preferably not more than 1/3rd filled during mixing.

7. The cycle time should be controlled at 20 minutes. A shorter time leads to inefficient mixing and no advantage accrues from extended cycles. The 20 minutes cycle gives a balanced labour schedule.

V. REFERENCES. *

Reference 1. Report No. 15.151. "Developments in Methods of Mixing Tracer, Incendiary and Flare Compositions" by C.J. Stairmand. Report MNE/R11/39.

Reference 2. Report MNE/R11/39. "Mixing of Smoke Compositions" by C.J. Stairmand. November, 1942.

Reference 3. Report MNE/R11/36. "Finex Sieving Machine" by C.J. Stairmand 29.9.42.

* Obtainable from the Director of Ordnance Factories (Filling).

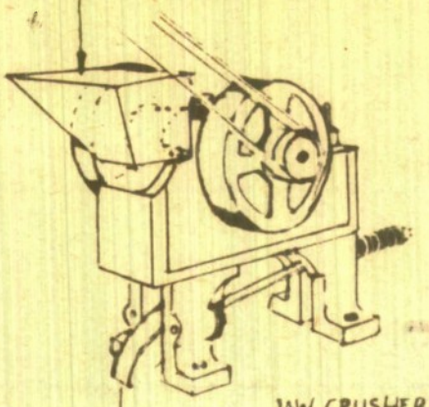
HEXACHLORETHANE

ZINC OXIDE

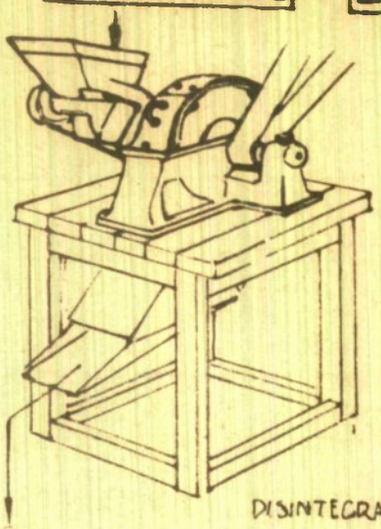
~~RESTRICTED~~

SODIUM CHROMATE

ZINC DUST



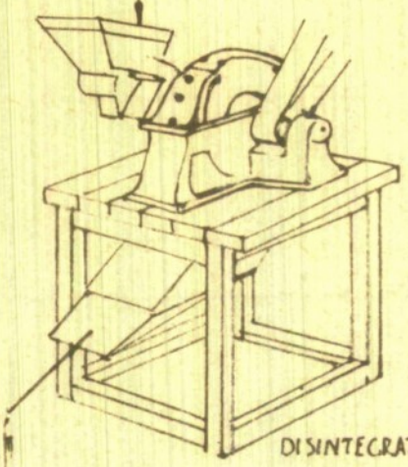
JAW CRUSHER



DISINTEGRATOR

WEIGH

WEIGH



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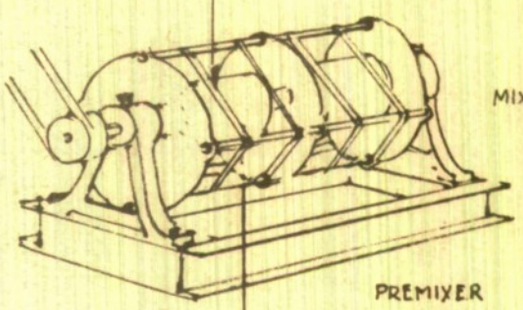
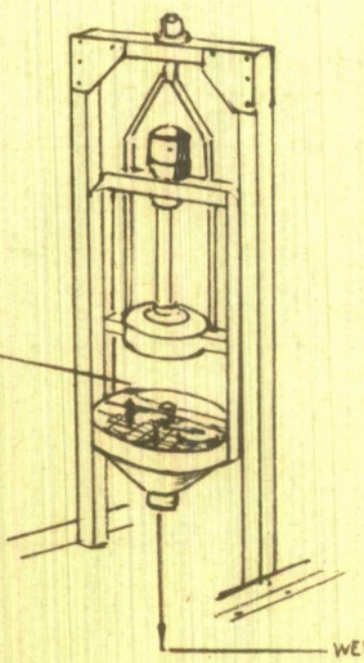


MIXING CANS

PREMIXER



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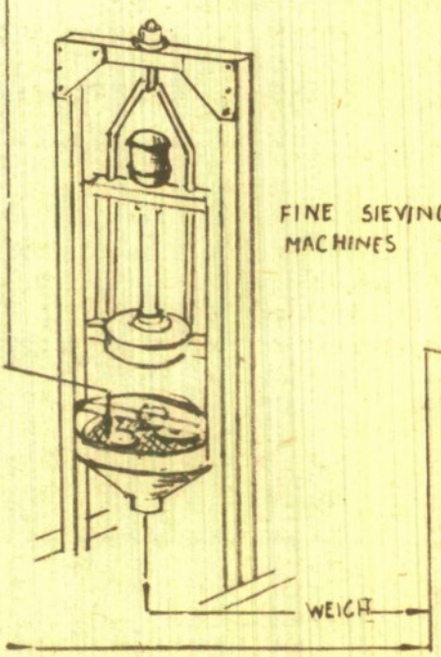
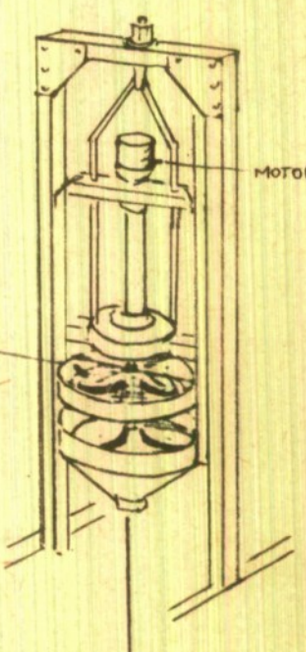
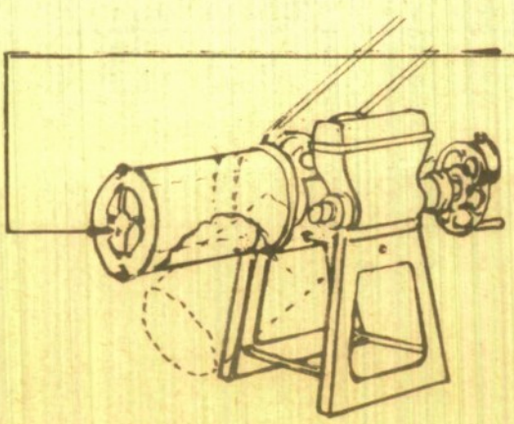


FINE SIEVING MACHINES

WEIGH



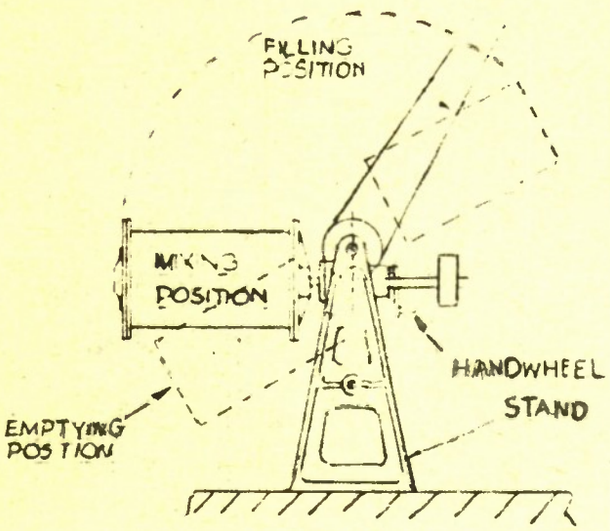
MOTOR



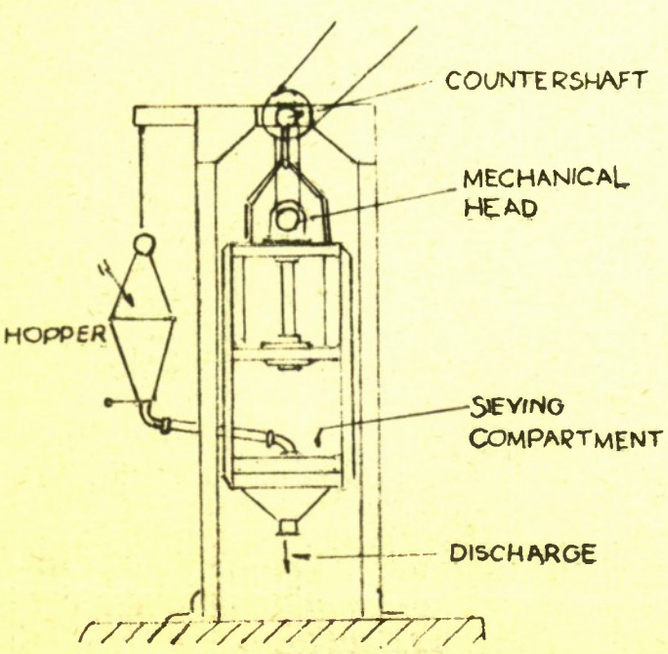
DRUM MIXER

250 Lb BATCHES

FLOW · SHEET · FOR · SMOKE · COMPOSITION · MIXING · PLANT



ARRANGEMENT OF DRUM MIXER
FOR 200-300 LBS BATCHES



FINEX BEVINS MACHINE

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